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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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10/809,681

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Shoso Shingubara

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EXAMINER

BAREFORD, KATHERINE A

ART UNIT

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1792

MAIL DATE

DELIVERY MODE

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PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 10/809,681	Applicant(s) SHINGUBARA ET AL.	
	Examiner Katherine A. Bareford	Art Unit 1792	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 26 November 2007.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-13 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-13 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08)
Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on November 26, 2007 has been entered.

The amendment provided with the RCE submission of November 26, 2007 has been entered. With the entry of the amendment claims 1-13 are pending for examination, including new claims 8-13.

Claim Objections

2. The objection to claim 5 is withdrawn due to the clarifying amendment of November 26, 2007 to clarify what the barrier metal film is immersed in.

Claim Rejections - 35 USC § 112

3. The rejection of claim 5 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement is withdrawn due to the clarifying

amendment of November 26, 2007 to clarify what the barrier metal film is actually immersed in.

Double Patenting

4. Applicant is advised that should claim 6 be found allowable, claim 12 will be objected to under 37 CFR 1.75 as being a substantial duplicate thereof. When two claims in an application are duplicates or else are so close in content that they both cover the same thing, despite a slight difference in wording, it is proper after allowing one claim to object to the other as being a substantial duplicate of the allowed claim. See MPEP § 706.03(k).

Applicant has provided that claim 12 depends from claim 1, so it substantially duplicates claim 6, which also depends from claim 1. If applicant intended claim 12 to depend from claim 8, the claim should be amended to clarify.

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

6. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

7. Claims 1, 2, 4, 7-9 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted state of the prior art in view of Kawanoue et al (US 6229211).

The admitted state of the prior art, at pages 1-4 of the specification, teaches a known process for making embedded multilevel interconnects. For example, the process includes forming a hole portion in an insulating layer (page 2, line 25 through page 3, line 7). Then a barrier metal film of TaN is formed on the hole portion walls, by a method such as sputtering (page 3, lines 5-10). An oxide film formed on a surface of the barrier metal film is removed by etching (page 3, lines 5-15). Then, an electroless plating step of immersing the barrier metal film in a plating liquid comprising copper, thereby forming an electroless copper plating film on the barrier metal film occurs (page 3, lines 15-18).

Claims 7, 13: Finally, an electrolytic copper plating step occurs over the electroless copper plating film (which thereby acts as the seed layer for the electrolytic plating) (page 3, lines 18-21).

The admitted state of the prior art teaches all the features of these claims except (1) the element composition ratio of N/Ta (claims 1, 2), (2) the removal step is such that the barrier metal film is left in such a manner that it entirely covers the inner wall of the hole portion (claim 4) and (3) by controlling the composition and thickness of the barrier metal film, after the removal step the barrier metal film is left in such a manner that it essentially entirely covers the inner wall of the hole portion (claim 8).

However, Kawanoue teaches barrier metal films that can be used when forming embedded multilevel interconnection, where a copper layer is applied over the barrier films. Column 1, lines 5-40, column 8, lines 5-25 and Figures 3B and 3D, for example. A barrier film is applied to a hole portion area of an insulating layer. Figures 3B and 3D, for example, and column 8, lines 5-25. The barrier film can be tantalum nitride, and can be formed by sputtering. Column 3, lines 50-65 and column 8, lines 5-25 and 50-65. The ratio of nitrogen to tantalum (N/Ta) can be 0.87, for example. Figures 3B and 3D, for example, and column 8, lines 5-25 (film 34 or film 38). Therefore, when depositing, the composition of the barrier metal film is controlled (see column 7, lines 55-60). The thickness of the applied barrier metal film is also controlled. See column 7, lines 45-55 (20 nm on the bottom and 5 nm on the side walls). When copper is applied over the

barrier film, the barrier film is provided in such a manner that it entirely covers the inner wall of the hole portion. Figures 3A and 3B and column 7, lines 45-55.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the admitted state of the prior art to use a N/Ta ratio of 0.87, for example, and control the composition of the barrier metal film applied to provide this ratio, as suggested by Kawanoue with an expectation of desirable protective barrier action, because the admitted state of the prior art teaches the desire to provide TaN films by a method such as sputtering for forming barrier films for embedded multilevel interconnects, and Kawanoue teaches that TaN films provided by a method such as sputtering for forming barrier films for embedded multilevel interconnects can acceptably have a N/Ta ratio of 0.87. Furthermore, it would also have been obvious to modify the admitted state of the prior art to perform the removal step such that the barrier metal film is left in such a manner that it entirely covers the inner wall of the hole portion when copper coating is performed as suggested by Kawanoue in order to provide a desirable copper plating, because the admitted state of the prior art provides applying a barrier film to hole walls and etching the barrier film (to remove oxide) prior to applying copper and Kawanoue teaches that it is well known when applying a barrier film to hole walls prior to applying copper, to have the barrier film covering all of the hole walls before applying the copper. Furthermore, it would also have been obvious to modify the admitted state of the prior art to control the thickness of the barrier metal film when applying as suggested by Kawanoue to provide

✓/b predicable repeatable results, because the admitted state of the prior art ^{teaches the} ~~he~~ desire to
provide TaN films by a method such as sputtering for forming barrier films for
embedded multilevel interconnects, and Kawanoue teaches that TaN films provided by
a method such as sputtering for forming barrier films for embedded multilevel
✓/b interconnects ^{are} ~~is~~ desirably applied to a controlled thickness such as 20 nm on the bottom
and 5 nm on the side walls, and further shows that this thickness covers all the hole
walls before applying the copper, and one of ordinary skill in the art would wish to
apply coatings to a controlled repeatable thickness for repeatable results. As to the
claimed "by controlling the composition and the thickness of the barrier metal film,
after removal of the oxide film the barrier metal film essentially entirely covers the inner
wall of the hole portion, thereby preventing development of a void within the hole
portion" (claim 8), the fact that applicant has recognized another advantage which
would flow naturally from following the suggestion of the prior art cannot be the basis
for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*,
227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985). Here, the admitted state of the prior art
in view of Kawanoue provides applying the barrier metal film within the composition
range claimed and a thickness greater than that required by applicant for essentially
entirely covering the inner wall to prevent developments of void, and therefore the
claimed "after removal of the oxide film the barrier metal film essentially entirely
covers the inner wall of the hole portion, thereby preventing development of a void
within the hole portion" occurs.

8. Claims 3 and 10 are rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted state of the prior art in view of Kawanoue as applied to claims 1, 2, 4, 7-9 and 13 above, and further in view of Miyamoto (US 6284649).

The admitted state of the prior art in view of Kawanoue teaches all the features of these claims except that the TaN film is formed by plasma nitriding tantalum.

However, Miyamoto teaches a method of forming a tantalum nitride barrier layer to use in semiconductor devices, where the barrier layer is applied in a connection hole and then Cu is applied over the barrier layer. Column 1, line 35 through column 2, line 10. Miyamoto teaches that one way to achieve the tantalum nitride barrier layer is to apply a tantalum layer and then performing plasma nitriding to form the tantalum nitride. Column 10, lines 1-55 and column 9, lines 1-30.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the admitted state of the prior art in view of Kawanoue to achieve the tantalum nitride barrier film by applying tantalum and plasma nitriding as suggested by Miyamoto in order to provide a desirable barrier film, because the admitted state of the prior art in view of Kawanoue teaches forming a TaN barrier film onto which copper is to be applied, and Miyamoto teaches that a well known way of achieving such a TaN barrier layer is by applying tantalum and then plasma nitriding.

9. Claims 5-6 and 11-12 are rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted state of the prior art in view of Kawanoue as applied to claims 1, 2, 4, 7-9 and 13 above, and further in view of Wang et al "Electroless Plating of Copper on Metal-Nitride Diffusion Barriers Initiated by Displacement Plating" (Hereinafter Wang Electroless Article).

The admitted state of the prior art in view of Kawanoue teaches all the features of these claims except the acid system used for the removal of oxide (claim 5, 11) and the reducing agent for the electroless plating (claim 6, 12). The admitted state of the prior art, page 3, lines 10-15, teaches to remove the surface of the barrier film by etching.

However, Wang Electroless Article teaches a method of forming interconnects, where tantalum nitride is used as a barrier material. Page C38. The tantalum nitride is applied to the surface by a process such as sputtering. Page C38, column 2. Then the substrate with TaN is etched with HF: HNO₃:H₂O solution (hydrofluoric acid: nitric acid: and water - a diluent of hydrofluoric acid). Page C38, column 2 (the use of the water would also provide that diluted hydrofluoric acid is present). This removes the oxide from the surface. Pages C38-C39 (see paragraph bridging pages). Then electroless copper plating is performed. Page C38, column 2. Moreover, Wang Electroless Article teaches that the reducing agent used for the electroless copper plating bath can be glyoxylic acid. Page C38, column 2.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the admitted state of the prior art in view of Kawanoue

to etch treat the tantalum nitride film by immersing in a solution of hydrofluoric acid, nitric acid, and a diluent of hydrofluoric acid to remove oxide as suggested by Wang Electroless Article in order to provide a desirable barrier film, because the admitted state of the prior art in view of Kawanoue teaches forming a TaN barrier film onto which copper is to be applied and etching before copper plating, and Wang Electroless Article teaches that a well known way of achieving such etching for a TaN barrier layer before copper plating is by applying solution treating, which would suggest immersion to apply the solution, with solution of hydrofluoric acid, nitric acid and a diluent of hydrofluoric acid to remove oxide. Thus, for example, a mixture of hydrofluoric acid and nitric acid would be used. It would further have been obvious to modify the admitted state of the prior art in view of Kawanoue to use glyoxylic acid as the reducing agent for the copper electroless plating bath as suggested by Wang Electroless Article in order to provide a desirable copper plating, because the admitted state of the prior art in view of Kawanoue teaches forming a TaN barrier film onto which copper is applied by electroless plating, and Wang Electroless Article teaches that a well known way of achieving such electroless plating on a TaN barrier film is by using glyoxylic acid as the reducing agent for the electroless plating bath.

10. The rejection of claim 5 is rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted state of the prior art in view of Wang et al "Suppression of native oxide growth in sputtered TaN films and its application to Cu electroless plating"

(Hereinafter Wang Suppression Article) is withdrawn due to the amendment of November 26, 2007 to claim 5 to provide material taught by the foreign priority document as shown in the translation of June 26, 2007 of the foreign priority papers.

Response to Arguments

11. Applicant's arguments filed November 26, 2007 have been fully considered but they are not persuasive.

VB ~~(A)~~ As to the rejection of claims 1+ under 35 USC 103 using the admitted state of the prior art in view of Kawanoue, applicant argues that the present invention prevents development of voids during electroless plating where a barrier metal film is immersed in a plating liquid, but on the other hand, Kawanoue does not use an electroless plating process for forming the embedded Cu layer, but instead uses a Cu damascene process. Therefore, according to applicant, there is no motivation and/or suggestion in Kawanoue for preventing the formation of voids. Furthermore, applicant argues that new independent claim 8 states that the barrier metal film has an element compositional ratio of nitrogen to tantalum of $0.3 \leq N/Ta \leq 1.5$, and also that the initial thickness of the barrier metal film is controlled so that, after oxidation, the barrier metal film essentially entirely covers an inner wall of the hole portion, and thereby prevents development of a void during plating. According to applicant, even if Kawanoue were to suggest a N/Ta ratio of 0.87, removal of the oxide film might still result in complete removal of the barrier metal film, at least in some locations, if the barrier metal film were not applied

thickly enough at the outset, and choosing an initial thickness of the barrier metal film is also an important factor and Kawanoue does not teach or suggest such a factor.

The Examiner has reviewed these arguments, however, the rejection is maintained. First, as to claims 1-7 and 12, applicant argues that their invention prevents voids. However, this is not claimed as to claim 1-7 and 12. Although the claims are interpreted in light of the specification, limitations from the specification are not read into the claims. See *In re Van Geuns*, 988 F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993). The only question is--when using a tantalum and nitrogen containing barrier film would using the claimed N/Ta ratio be suggested. The Examiner has provided Kawanoue to provide the suggestion of using such a ratio. Applicant has argued that Kawanoue does not provide the electroless plating, so there is no motivation and/or suggestion for the preventing the formation of voids, and thus one of skill in the art would not be suggested to use an particular N/Ta ratio as shown in Kawanoue. However, the Examiner notes that the rejection uses the admitted state of the prior art as the primary reference, and as discussed in the rejection above, this reference teaches both the electroless plating of copper and the sputtering application of tantalum and nitrogen in the form of tantalum nitride films as the barrier metal film underlying the copper plating. The Examiner has provided Kawnoue as providing that, as discussed in the rejection above, sputtered tantalum nitride films barrier metal films over which copper is to be applied can desirably have an N/Ta ratio of 0.87. It would be suggested to use such an N/Ta ratio in the process of the admitted state of the prior art in order to

provide a desirable metal barrier film protective action, as discussed in the rejection above. It is not required that the references teach that this usage is for preventing the formation of voids, because (1) it is not claimed as discussed above, and (2) furthermore, even if the prevention of voids was claimed, the fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985).

As to claims 8-11 and 13, which claim controlling the composition ratio of N/Ta within the range claimed and the thickness so that "by controlling the composition and the thickness of the barrier metal film, after removal of the oxide film the barrier metal film essentially entirely covers the inner wall of the hole portion, thereby preventing development of a void within the hole portion", this is also suggested by the combination of the admitted state of the prior art and Kawanoue. As discussed in the rejection above, the admitted state of the prior art in view of Kawanoue provides the suggestion to control the composition ratio N/Ta to a value within the claimed range. The admitted state of the prior art in view of Kawanoue further provides the suggestion to control the thickness of the applied barrier metal film to a thickness such as 20 nm on the bottom and 5 nm on the side walls. As to the claimed "by controlling the composition and the thickness of the barrier metal film, after removal of the oxide film the barrier metal film essentially entirely covers the inner wall of the hole portion,

thereby preventing development of a void within the hole portion" (as provided in claim 8), the fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985). Here, the admitted state of the prior art in view of Kawanoue provides applying the barrier metal film within the composition range claimed and a thickness greater than that required by applicant for essentially entirely covering the inner wall to prevent developments of void (the paragraph bridging pages 5-6 of the specification indicates film thickness of 1 nm or less can be used, and the paragraph at page 10, lines 5-10 of the specification indicates an example of a film thickness of 2 nm is sufficient), and therefore the claimed "after removal of the oxide film the barrier metal film essentially entirely covers the inner wall of the hole portion, thereby preventing development of a void within the hole portion" occurs.

Conclusion


Any inquiry concerning this communication or earlier communications from the examiner should be directed to Katherine A. Bareford whose telephone number is (571) 272-1413. The examiner can normally be reached on M-F(6:00-3:30) with the First Friday Off.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Timothy Meeks can be reached on (571) 272-1423. The fax phone numbers for the organization where this application or proceeding is assigned are (571) 273-8300 for regular communications and for After Final communications.

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Other inquiries can be directed to the Tech Center 1700 telephone number at (571) 272-1700.

Furthermore, information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).


KATHERINE BAREFORD
PRIMARY EXAMINER